# EXPLORING NEPTUNE'S GARDENS: FROM LANDLUBBER TO REEF BIOLOGIST

BY

KLAUS RÜTZLER

## INTRODUCTION

This special issue of ARB provides an excellent opportunity to reminisce, without doubt a satisfying experience, even though it is safe to assume that few except the volume editor will read these accounts. But it may be useful for our successors to have a reference that may explain old mistakes, or at least point to the motivation and thinking that guided us, thus paving the way for interpretation, correction, and improvement.

I am not really sure what to call myself professionally, what my real scientific persona may be, though many would say I am a sponge biologist, with a strong inclination toward ecology. Yet my interests range from rocky (Mediterranean) shores to reefs and mangroves, and I have strayed into the systematics, morphology, and biology of microbes, algae, and entoprocts, mostly sponge symbionts, and some "pseudosponges" that turned out to be agglutinating foraminiferans. I have also been an expedition leader and research coordinator and facilitator, probably because diving became a research discipline for me during the early pioneering years when scuba shops were not just around the corner and every piece of equipment had to be invented or copied from someone else's.

My father, Karl Rützler, was an accountant, my mother, Maria Hermine, a "homemaker." Both loved nature and climbed (particularly my father), hiked, and skied in the Alps of our native Tyrol and spent summer vacations touring Austria and the surrounding countries and swimming (particularly my mother) in lakes and off the rocky coasts of Italy, Slovenia, and Croatia. They spent the rest of their leisure time at the theater or the opera, or listening to classical music. I was dragged along but disappointed my parents by not wanting to become a classical pianist and refusing to learn to swim until I turned seven.

My childhood years were strongly influenced by *Das gläserne Unterseeboot* (The Glass Submarine); I can't remember the author and don't know what happened to my copy of the book, but its story remains vivid. It was about a U-Boot designer in the 1930s who built a special model with large windows cut into the hull. He took his family, wife, and two children on a journey around the world, discovering foreign lands and studying sea life along the way, from the frigid rocky slopes of the island of

Department of Systematic Biology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560-0163

Helgoland (North Sea) to the splendid coral reefs of Pacific atolls. The book had many pictures, and there is no doubt that it was instrumental in fixing my gaze on the sea. These early tendencies were further reinforced by Jules Verne's *Twenty Thousand Leagues Under the Sea.* Since my parent's resources did not allow for a submarine of glass or any other material, I had to direct my interests to other means of ocean exploration. By the time I was 17, I had read all the books by the pioneers of "skin diving" and underwater photography, such as Hans Hass (e.g., Hass, 1947), Jaques-Yves Cousteau (e.g., Cousteau and Dumas, 1953), and Dimitri Rébicoff (e.g., Rébicoff, 1956). After reading several versions of Paul de Kruif's *Microbe Hunters* (e.g., de Kruif, 1926) I became fascinated by all kinds of microscopic creatures at the bottom of the evolutionary tree, and I shall be forever grateful to my parents for giving me a good-quality microscope for my sixteenth birthday despite its considerable cost (Figure 1).

**Figure 1.** At age 16 in Vienna, with new Reichert RC microscope examining life forms in pond water.

Since my ventures into the field of scientific diving for the purpose of sponge research are described elsewhere (Rützler, 1996), I shall limit the following paragraphs to a few highlights of my career that I did not mention there.

## MATERIALS AND METHODS

This topic can be summarized as follows: Arrived by the traditional means of human reproduction, with the early years and primary education in Vienna (compromised by Adolf Hitler's maniacal expansionism and retaliation by Allied Forces). Life then consisted of voracious reading of biology-related literature, tending to aquaria filled with local pond life, and discoveries under the microscope donated by understanding parents. Secondary and university education also took place in Vienna.

Then came post–World War II travel through Austria and Italy by hitch-hiking and motor scooter to dive in lakes and finally in the sea. Scrap metal, rubber, plexiglass, and cookware were rededicated to the manufacture of personal dive gear. Student course work and a Ph.D. dissertation were completed in the Croatian Adriatic.

## RESULTS

This is a chronological report on key events as I remember them without thorough research of dates and details. Though I can mention only a few individuals

who helped and influenced me during my professional development, I have not forgotten any of the others.

## The Early Years

*The Diving Adventure.* My first diving gear, in the early 1950s, was built by myself from scrap, with the aid of photographs and figures in the aforementioned books. Nothing along these lines was commercially available in post–World War II Austria, not even a mask and fins. Those were the days of breath-held or aqualung diving, and using a snorkel would certainly have been considered unprofessional. Luckily, I eventually found other sports-diving enthusiasts who had access to "industrial" facilities such as rubber presses and aluminum-melting furnaces so was able to custom-build the necessary gear without undue cost. Eventually, my original jerry-rigged oxygen rebreather was replaced by a much healthier compressed-air regulator ("aqualung"). The pressure cooker that served as my first underwater housing for a spring-wound Robot 24 x 24 mm camera (activated by a stuffing-box-sealed trigger rod) was traded in for a compact cast-aluminum case with multiple-function controls.

Despite rapid technological advances in compressed-air diving, this pleasurable and safe (if done in moderation) technique remained out of the reach of my meager resources. It was also difficult to get access to compressors. Most underwater activities through my late twenties consisted of free diving to a depth of 6 to 8 m, although my colleagues and I were able to reach below 20 m after weeks of getting in shape.

My earliest diving excursions took place in the frigid lakes of Austria, where crayfish, pike, and catfish provided the excitement. There I saw my first live sponges, one of the few freshwater species. These sponges look more like a patch of moss than an animal and were not fully appreciated by me.

My first dives in the sea were in the Adriatic near Umag (now in Slovenia) and Sistiana (near Trieste, Italy), along stretches of rocky shore covered by seaweed and in waters teaming with fish and colorful invertebrates. My companions at the time included a group of dare-devil physicians who had formed a dive club in Carinthia (southern Austria) and my good friend from high school days, Hans Pulpan (Puli), now a geophysicist in Fairbanks, Alaska. These trips were a great adventure for us all, though my friends cared less about the biology of the exciting habitats we visited than the diving. The following summers, Puli and I (and one or another game friend from high school) visited the Mediterranean islands of Elba and Corsica. We hitchhiked from Vienna to Livorno, in northwestern Italy, where ferries depart for both islands. We explored their beautiful steep rocky shores to our heart's content and had no trouble at either location finding a fisherman with a few fields and a vineyard by the coast who would let us pitch a tent and use his freshwater well, and who would sell us grapes, figs, bread, tomatoes, some fish, and a little red wine. During these trips we contributed very little to science but a whole lot to our personal development, which included honing our skills at catching fish, lobster, and squid, or finding mussels and oysters, and cooking them on small camp fires. We soon became adept at peeling the fruit of *Opuntia* (prickly pears) without getting thousands of hairlike spines into our fingers and learned that

hooks and hand lines were more desirable fishing tools than our crude homemade speargun (then still legal), which was difficult to aim precisely and made big holes in the poor victims. But the best part of it all was observing and photographing sea life in situ.

*Going Professional.* My career in marine biology began in the fall of 1955, when I entered the University of Vienna and met Rupert Riedl, the teacher who influenced my professional life the most (and that of a good number of fellow students, many still among my best friends). At the time, Rupert was "assistant" to the university's one and only full Professor of Zoology (a comparative morphologist with no interest in the sea). Under the university's antiquated system, Rupert had no students of his own but could act as a dissertation adviser. Although I was far from needing one of those, he recognized my enthusiasm and got me on the right track from the outset. I was put into a laboratory together with two other students who were assisting him in his research (between attending lectures and labs) and were about to start their doctoral dissertations. The senior one was Ernst Kirsteuer, who became a fine histologist and world expert in nemertean biology (ending up as curator and chairman of invertebrates at New York's American Museum of Natural History). The other student was Hellmuth Forstner, a rather independent fellow with a great knack for setting up aquarium systems, understanding decapod crustaceans, picking up pretty women, and mastering biophysics; he retired last year from his position as physiologist at the University of Innsbruck. Together we had a fantastically good time and developed strong bonds with each other and the sea we loved, the Mediterranean.

Rupert's research in those days revolved around the systematics and ecology of hydroids and turbellarian worms. He and colleagues under his leadership had returned from a series of diving and collecting expeditions to the Gulf of Sorrento, south of Naples, and were about to complete a series of monographs dealing with the diversity and quantitative distribution of animals and plants inside and outside intertidal caves. Lucky for me, his "sponge man," Kurt Russ, a trained agricultural entomologist who wanted to experience the sea, was tied up with his insects. Russ had neither the time nor the inclination to describe the sponges he had collected and sorted during his trip or to deal with the statistics explaining their distribution. So the job of writing up the results and publishing them as coauthor fell to me. Needless to say, I felt honored to be accepted into the team and to be given a chance to write something that would actually be published (Russ and Rützler, 1959).

Two years later, I was ready to start a dissertation. With Rupert's encouragement, I continued working with sponges and the ecology of marine caves where they abound, and where the lack of light keeps algae, their principal and fast-growing space competitors, at bay. Colorful cave sponges had already caught my eye before then because they made excellent subjects for underwater photography (we used disposable-bulb flashguns in those days), but no one seemed to be around who could identify them. Fortunately, before my mistakes in self-taught systematics had become too serious, Rupert connected me with an Italian colleague, sponge biologist Michele Sarà, then professor in Naples. Michele imbued me with confidence, for he treated me like a

colleague and old friend and seemed pleased with my work. We collaborated in the description of a new sponge, my second publication.

*The First Austrian Indo-West-Pacific Expedition.* This memorable adventure with a pretentious title was planned with my friend Ernst Kirsteuer. Our goal was to dive on a coral reef and experience its splendor before completing our dissertations and their defense and having to face the real world of employment (considered equal to enslavement). Initially, we hoped to persuade a larger group of colleagues to participate and to obtain the support of a well-heeled sponsor, who would readily see, as we did,

**Figure 2.** In May 1959, preparing the field laboratory on a beach at Tany kely, a small island off Nosy Bé (the land mass of Madagascar is in the background) (top). At the 16 mm Eumig movie camera filming marine life in a variety of photo cuvettes (bottom).

that our proposed endeavor had great import for humankind. Our destination was to be the Seychelles, where we would undertake the First Austrian Seychelles Expedition. Early on, we learned some valuable lessons about organizing people and fund-raising, above all, that both are exceedingly difficult to do, especially by greenhorns like us. After our proposed collaborators had dropped out one by one and we were unable to arrange affordable passage to the Seychelles, we switched course. We found that a cabin was available on a French freighter (for the price of deck passage) going from Marseille to Nosy Bé, Madagascar. There we enjoyed the hospitality of the director of a French oceanographic station, who provided inexpensive field facilities: a government-owned storage shed on a tiny offshore reef island, Tany kely ("small island") (Figures 2, 3).

**Figure 3.** Barracuda for dinner at Tany kely; spearfishing, accepted and legal as a sport in those days (1959/60), provided food and was an excellent training device for breath-held diving (left). Exploring a coastal swamp on Nosy Bé, where rain forest meets mangrove (right).

Supported by fish that we caught, local rice and coconut, and some 10 crates of food and other donations-in- kind from sponsors back home, we spent ten months on the island (during 1959/60), living in a small tent and working in a field lab installed on the porch of the thatched-roof shed, with only one three-week break when we visited the Island of Réunion. Our expedition crates served as lab benches. We had brought along borrowed or donated dive equipment, microscopes, movie and still cameras, photo cuvettes, fixatives, darkroom supplies, and so on. The Nosy Bé lab loaned us one dive tank with regulator (the underwater cameraman of the day got to use it) and a small aluminum dinghy to get around near shore. From this base, we conducted quite a

thorough study of sponges and nemerteans of the small fringing reef that was only 20 meters away from the sweaty air mattresses that served as our beds. We photographed animals and plants under water and close up and produced a one-hour documentary film (16 mm format) that was later shown on Austrian television and of course, along with many of our transparencies, in numerous lectures to the public. Among other discoveries, we observed periodic gathering of the voracious crown-of- thorns starfish *(Acanthaster)*, many years before this phenomenon was reported in the literature and led to worldwide concern for the survival of the planet's reefs. After almost a year, we returned to our alma mater, maybe not a lot smarter than when we had left but certainly richer in experience and with a working knowledge of Sakalawa French. It was now time to finish my dissertation (Rützler, 1965) and get serious about a professional life.

## Coming to America

*At the MCZ.* After graduating in 1963, I was offered a life-changing opportunity for postdoctoral work at Harvard's Museum of Comparative Zoology. Renowned evolutionary biologist and then MCZ Director Ernst Mayr needed someone to reorganize and reevaluate certain marine invertebrate collections, and I just happened to be available and (thanks to Ruper Riedl, who also recommended me) had the taxonomic knowledge to do the job. Ernst encouraged me to continue my research on sponges and arranged for a grant that allowed me a one-month stay at the old Lerner Marine Laboratory (of the American Museum of Natural History), on Bimini, Bahamas. My travels during that time took me to various places, including Washington, D.C., where my Harvard buddy Ken Boss (he graduated while I was there and accepted a job at the Smithsonian- based National Marine Fisheries Service) introduced me to Don Squires, chairman of the newly created Department of Invertebrate Zoology. Don wanted a sponge expert but no one was available in the United States. I was hoping to hook up with a dynamic and expanding center of systematic and evolutionary biology, which was not far from what Don had in mind. He told me he was about to establish a powerhouse of marine research where fieldwork, which was so important to me, would be at center stage for anyone who agreed to join the team. Though I had to leave the country for two years in order to get an immigration visa, he said the paperwork would be done in time (and he was quite right in his predictions). While still at Harvard, I was "found" by some of the organizers of the International Indian Ocean Expedition (IIOE) at nearby Woods Hole Oceanographic Institution and offered travel expenses and research space on the participating Stanford-owned three-mast schooner *Te Vega* later that year. This promised to be an outstanding experience and despite my misgivings about boats (which invariably made me seasick, even while still in the harbor), I signed up.

*The* Te Vega *Cruise.* When I finally got to meet her, in Singapore Harbor, it was love at first sight. The *Te Vega*, built in Germany in 1928, with a steel hull and mahogany decks and fittings, was, for a quintessential landlubber like me, a dream of a sailing ship. Although the *Te Vega* was refitted as a research vessel, with an ugly yellow-painted lab structure on its lovely wooden deck, it was sleek and elegant and

became "home" for the next three months. I was never seasick on the *Te Vega.* It was very stable in the water, counterbalanced by a heavy, deep-draft keel that gave the ship a gentle pitch, with hardly any rolling at all (to be sure, I started out with a substantial dose of Dramamine).

This cruise under the auspices of the IIOE was designed primarily for the investigation of shallow (scuba-depth) water, particularly the reefs there. Hence the *Te Vega* was outfitted with whalers and outboard motors, scuba, and, to my great delight, a complete, brand new Rolleiflex underwater camera system with flash (this outfit, called Rolleimarine, was designed by Austrian underwater pioneer Hans Hass in cooperation with the camera company). I was assigned the camera and tested it for close-up and correct flash exposure, using Ektachrome processing in the ship's own darkroom.

**Figure 4.** As postdoctoral Fellow in 1963 (third from left, with graduate students), on board the research vessel Te Vega (Stanford University) off Sumatra during the International Indian Ocean Expedition.

There were 15 crew members, all skilled volunteers and many expert divers. Five, including myself, were scientists, under the leadership of Rolf Bolin, a Stanford ichthyologist (and personal friend of both Ed Ricketts and John Steinbeck, hence a source of fascinating tales). Seven were graduate students, who served as our assistants and thus gained hands-on training in our special fields (Figure 4). My other colleagues among the senior scientists were Alan Kohn, a *Conus* (poisonous marine snail) specialist from the University of Washington; Joe Rosewater, malacologist at the Smithsonian (who later became a close friend); and Llewella Colinvaux, my principal dive buddy and specialist on the ubiquitous calcified reef algal genus *Halimeda.*

Starting from Singapore, our cruise headed north along the west coast of Malaysia and Thailand, crossed the northern tip of Sumatra, turned south, stopping at many remote and seldom-visited (by scientists) islands of the Nias and Mentawai group, all the way to Mega. Just before we turned northwest toward Colombo, *Te Vega'* s mainshaft broke and the cruise, lacking wind for sailing at this point, ended somewhat prematurely in the harbor of Padang, Sumatra.

## At the Smithsonian

*The Immigrant.* After returning to Austria from the Indian Ocean, I knew that there would be a gap when I had to fend for myself. I teamed up with my friend Hellmuth Forstner (who had just finished a postdoc at the marine laboratory in

Plymouth) and wrote a proposal to an Austrian science fund (the President T. Körner Award), which was accepted and provided enough support for a project at the University of Vienna and the Marine Biological Institute at Rovinj (now in Croatia). The study explored the idea that individual marine benthic organisms are subjected to microclimatic conditions that are different from and shorter lived than parameters measured by the precise instruments (such as mercury thermometers, devices for sampling and analyzing water, mechanical current meters, radiometers, and Secchi discs) ordinarily used to monitor large-scale and slow oceanographic processes. Using the newest (then) semiconductor technology (and Hellmuth's electronic skills), we designed, machined, and assembled miniature instrumentation that would record the microclimate surrounding, say, a sponge. We field-tested the new equipment with results good enough to publish, although the principal paper (Forstner and Rützler, 1970) did not appear in print until much later.

With my immigration visa in hand, I reported for duty at the National Museum of Natural History in October of 1965. I was warmly welcomed by my new colleagues and started to look for opportunities to conduct field research in the Caribbean. Almost instantly, I was invited to be the first marine biologist to participate in the ongoing Biological Survey of Dominica (West Indies). Several Museum colleagues and outside collaborators were already studying the terrestrial fauna and flora of this beautiful volcanic island. I was given funds to purchase a dive compressor with tanks and other field equipment and to bring along a collaborator as dive partner. Since there were no divers in my department, I asked Ernst Kirsteuer who was then at the American Museum of Natural History in New York. We established two field sites at opposite coasts of Dominica, windward and leeward, and collected the same kind of samples as at Tany kely, Madagascar: sponges for me, dead coral rock for nermertean extraction for him.

The fieldwork in Dominica was followed by excursions to Bermuda, Puerto Rico and the Virgin Islands, Santa Marta (Colombia), Bimini (Bahamas), and Jamaica, where I examined sponges potentially useful for pharmacological purposes. I also returned to the Mediterranean for similar work and a special project on commercial sponges in Tunisia funded by Public Law 480 funds, which derived from money owed to the United States by countries with nonconvertible currencies and made available for research applications. Tunisia already had a Smithsonian- operated Mediterranean Marine Sorting Center (MMSC) in place for pre-identifying and distributing to specialists organisms and sediment samples collected by various expeditions. It was to serve as a staging area for my project. Since the host country had the right to determine which kind of research could be conducted, I negotiated a permit for a commercial-sponge project, for the simple reason that Tunisia was looking for more applied research, with an immediate benefit, than we usually do and had a large but declining bath sponge industry. While examining several species of the commercial genera *Spongia* (bath sponge) and *Hippospongia* (horse sponge) and related noncommercial *Ircinia* and *Cacospongia* (Rützler, 1976), I was surprised to discover some useful biological facts relating to commercial quality and cultivation potential, such as the incorporation of an iron oxide in the primary elastic fibers. However, this work probably did little to improve the living standard of the local fishermen and merchants, who, I'm

certain, continue to sell nicely wrapped but substandard and overprocessed souvenir sponges to the tourists. Coincidentally, I was able to continue more academic work on my main interest at the time, the rock-excavating clionid sponges, though it was conducted with meager scientific equipment and supplies and without qualified assistance.

In the late 1960s, my long dormant attraction to Bermuda was revived with the arrival of Wolfgang Sterrer, a friend from university days who was now director of the Bermuda Biological Station (BBS). Back in Vienna, Wolfgang and I used to spend long evening hours pondering the meaning of life and where our careers might lead us. This friendship was enhanced when he came for a postdoctoral appointment with our mentor Rupert Riedl, then Professor of Zoology at the University of North Carolina at Chapel Hill, to study Gnathostomulida, an obscure (he would call it "enigmatic") worm group living in the grayish and bad-smelling deeper layer of poorly aerated marine sand, also known as sulfide ecosystem. We bonded further during a field trip to the Smithsonian Tropical Research Institute (STRI) in Panamá, where we were delegated to examine the effects of a major oil spill on the reef communities of Galeta Island near the Atlantic entrance to the Canal. We found that the reefs were doing well during this crisis as long as the oil floated on the water surface, beyond the reach of corals, but that the adjacent mangrove was seriously endangered because oil coating the stiltroots was clogging the air vents (lenticells) that supply oxygen to the mud-buried underground roots. This discovery, published as a trip report in *Bioscience* (Rützler and Sterrer, 1970), was later acknowledged as the first report on the biological effects of an oil spill in mangroves and led to a whole new chapter in my life. Soon after Wolfgang took the helm at BBS, he invited me to conduct some research there. I obtained a grant to support a study of bioerosion by sponges and set up lab facilities at the biostation, equipped with a photo-microscope and an inflatable boat with outboard motor that could take me over most of the Bermuda reef platform. In parallel with the work in Tunisia, I explored the systematics, fine-structure morphology, ecology, and rock-excavation mechanisms of the Clionidae and other calcium-carbonate-burrowing sponges (Rützler and Rieger, 1973; Rützler, 1974; 1975).

*Toujours Smithsonian–Marine Shallow-Water Ecosystems.* Though highly satisfying, my fieldwork at Bermuda was also "lonely." The ecologist in me had long wanted to hook up with other disciplines that would allow me to better understand the role of sponges within the community. It was clear that I needed to work with specialists in taxonomic groups other than Porifera and fields related to benthos ecology, such as physico- chemical micro-climatology, nutrient cycling and food chains, microbiology, reef geology, ecophysiology, competition, and symbiosis. Surprisingly, considering that I worked in a natural history museum and not a marine science institute, I found that colleagues in other departments were of a similar mind, and we started discussing the possibility of collaborative coral reef studies, recognizing that a group effort would be more scientifically productive and correlated and would attract more support if it were a highly visible team project. One day in the late 1960s, we decided to launch a multidisciplinary, long-term program named Investigations of Marine Shallow-Water Ecosystems (IMSWE), a rather generous title designed so it would not lock us into

studying just one ecosystem in a single biogeographic region, although our primary aim at the time was to investigate coral reefs. Our core group consisted of Ian Macintyre, a carbonate sedimentologist interested in the historical development of reefs; Arthur Dahl, a marine botanist working on fleshy algae ecology; Walter Adey, a paleoecologist and expert in crustose coralline algae and their role on reefs and rocky shores; and myself; as well as several associates, such as paleobiologists Porter Kier and Tom Waller, and invertebrate biologist Mary Rice. Soon after our initial meetings, we were joined by my postdoctoral collaborator Arnfried Antonius, an old friend from the University of Vienna and a specialist in microscopic marine worms who wanted to switch fields and study stony corals. Walter Adey led our first fund-raising effort, which brought a grant that allowed us to purchase some diving equipment and an inflatable boat with outboard motor to scout out Caribbean locations for the ideal site to start our program. We also connected with a new program at the National Science Foundation (which does not usually fund Smithsonian programs) called International Decade of Ocean Exploration, IDOE) and proposed to collaborate with a dozen other institutional applicants on a comprehensive, 10-year coral reef study. NSF awarded a project development grant, and Ian Macintyre was appointed lead investigator for the Smithsonian group. During phase one we conducted surveys of suitable study locations (Figure 5). We were looking for a site with high geological and biological diversity, low environmental impact by humans, and easy access. Credit goes to Arnfried Antonius, an active member of the survey team, for recommending Glover's Reef in Belize (then still British Honduras), a pristine atoll outside the largest barrier reef in the Western Hemisphere and an ideal geological formation for comparative research in the Indo-Pacific at a later date. The entire NSF- sponsored group was very enthusiastic about the location, and after an on-site workshop and development of a

**Figure 5.** With Arnfried Antonius (left) in 1970, loading a charter boat to explore reef sites in the Bahamas for the new IMSWE Program

**Figure 6.** Carrie Bow Cay on the barrier reef of Belize, aerial view (1975) looking north.

conceptual model of a reef ecosystem, a grand proposal was submitted for 10- year funding. Within a few weeks, we learned that our monumental effort had failed, that the proposal was rejected, and that we were back to where we had started.

It fell to Antonius and me to retrieve some equipment stored at Glover's Reef. We chartered a boat in Belize City for the trip. When we returned from the atoll, the boat crew aimed too far south and missed the Tobacco Cay cut across the barrier reef. Instead, we entered the great lagoon through a passage just south of a small, unfamiliar coral island (Figure 6). Stopping to examine the location, we found an unoccupied building bearing a sign that said "Welcome to Carrie Bow Cay."

*IMSWE–Belize.* Despite the initial setback in obtaining funding for our field research, we were convinced that Belize offered the best conditions to carry out our program. Glover's Reef and the two other off- shore atolls were too remote to provide affordable facilities, but the barrier reef and the huge lagoon offered unlimited access to all kinds of reefs, to large seagrass meadows, and to spectacular mangrove islands. The country was virtually undiscovered by tourists or developers, and Belize City was just two hours away by plane from Miami. Antonius had already determined that Pelican Beach Motel in Dangriga (Stan Creek District) on the mainland of Belize would keep our equipment in storage until we found a convenient research base. When we inquired about Carrie Bow Cay, we learned that it was the property and vacation place of Henry and Carrie Bowman, parents of the motel's owner, Henry Bowman Junior. It turned out that "Sir Henry" did not object to leasing part of Carrie Bow for our research program. In February 1972 we signed the deal that marked the founding of the Carrie Bow Marine Field Station (Figure 7). At this point I had also decided to stay in the United States and become a U.S. citizen, a double celebration.


**Figure 7.** Carrie Bow Cay looking southwest across the reef flat (1975); the low building to the left was the original laboratory-kitchen unit that also included one bedroom (left). Sign identifying the new use of the island as research base (right).

We initiated our program in Belize by mapping habitats, determining reef zonation, and conducting biological inventory (Figure 8). Ian Macintyre and colleagues probed the reef's past development. I collected sponges as part of the survey and studied

**Figure 8.** Preparing helium balloon (with Hans Pulpan, right) for reef mapping with remote control camera (1976) (top). Reflecting on biodiversity (1982; bottom).

their distributional ecology (Rützler, 1978), but I had also taken on the responsibility of coordinating the research and, with Arnfried Antonius as first station manager, the logistical maintenance of the field operation, including scientific facilities and diving and boating equipment. We prepared detailed reports on our results, maintained a rapidly growing program publication list, and were able to obtain a multitude of small in-house grants for travel that also helped maintain our simple research station. To our disappointment, administrators did not agree that large-scale support of a coral reef program and a field station should be one of the Institution's priorities. Upon our constant urging, however, an inquiry from the EXXON Corporation about a modest but multiyear donation to enhance the company's image in Central and South America was channeled our way, and we succeeded in attracting this source of funding.

When our results became more substantial, we decided to prepare a contributed volume to more convincingly demonstrate our abilities as a research team concentrating on one particular reef complex over the long term (Rützler and Macintyre, 1982). During his study of diversity and morphological variability of reef corals, Arnfried Antonius encountered many competitive interactions, including disease-like phenomena and started the new discipline of coral pathology. I continued some of this work on black-band disease to expand my experience in cyanobacterial systematics and biology from parallel studies of sponge symbionts (Rützler et al., 1983; Rützler, 1990).

*Launching SWAMP.* Every autumn, I traveled to the (then) EXXON headquarters in Manhattan to present our IMSWE coral-reef program's progress report and renewal proposal and pressed for an increase in support, with reasonable success. In the early 1980s, I was warned that the company might soon look for another project to fund. As it happened, my own interests at the time had focused on the fascinating sponge fauna of the Twin Cays mangrove, a lagoon island just 10 minutes by boat west of Carrie Bow Cay. Not only was the sponge fauna on subtidal mangrove roots and peat banks very rich, but other invertebrates, algae, seagrasses, fishes, and birds abounded in the area's deep channels, tidal creeks, interior lakes, ponds, and mudflats. The occasional crocodile, boa, and manatee lent an aura of mystery to the place. Because the body of water surrounding the island was often exchanged by tidal flushing, this was an ideal spot for underwater observation and photography by snorkeling.

On behalf of my IMSWE colleagues from the departments of Invertebrate Zoology, Paleobiology, Botany, and Vertebrate Zoology, I prepared a proposal for a study of the Twin Cays Mangrove ecosystem, dubbed the Smithsonian West Atlantic Mangrove Program, or SWAMP, certainly an appropriate acronym. EXXON agreed to renew its funding of our group, and we received a substantial Smithsonian Scholarly Studies Award. Ian Macintyre immediately agreed to core the peat base of the island to determine whether it was built on an old patch reef or some other base. Part of my overall plan was to analyze both the aquatic and terrestrial communities (Figure 9), and thus to invite yet another Museum department, entomology, to join the effort. This work would be reported in a semipopular monograph illustrated by artists working along with scientists in the field. This project (originally titled Art in a SWAMP and partly funded by the Smithsonian Women's Committee) continues to be successful, thanks in part to the contributions of talented scientific illustrators such as Ilka ("Candy") Feller, Molly Kelly Ryan, and Mary Parrish. With their help, we were able to show communities in three dimensions (including below the substrate) and over time, and were motivated to examine more carefully the properties of organisms, associations, textures, colors, and the patterns of distribution and behavior.

The collaboration with Candy Feller itself took on a new dimension when she decided to return to her early love, the biology of plants and insects, and to complete a dissertation on the Twin Cays mangrove. From then on, Candy collaborated with us as a postdoc (at the Smithsonian Environmental Research Center, or SERC) and mangrove expert (Rützler and Feller, 1996). Now a member of the SERC staff, she and nine colleagues from different disciplines and institutions recently landed a large, five-year NSF Biocomplexity grant to study nutrient production and cycling at Twin Cays.

**Figure 9.** Surveying the Twin Cays mangrove swamp in the Belize lagoon just west of Carrie Bow Cay (1983). Tidal canals are navigated by inflatable boat (left); small fishes in ponds and lakes are caught (when lucky) by throw net (top right); sponges on mangrove stilt roots and peat banks are studied by mask and snorkel (bottom right).

*Caribbean Coral Reef Ecosystems.* In 1986 our highly improvised financing (both EXXON and Scholarly Studies support had ceased by then) received a boost from an unexpected source. Congress, under the Caribbean Basin Initiative, authorized an increase in our Museum's budget for a program based on the IMSWE–SWAMP study. It was named the Caribbean Coral Reef Ecosystems Program (CCRE). I was appointed CCRE's scientific director by then National Museum of Natural History Director Richard Fiske, and Marsha Sitnik became the program administrator, to help me jump bureaucratic hurdles and streamline logistics. This infusion of new support allowed us not only to continue current projects but also to remodel the old, termite-riddled buildings on Carrie Bow Cay that served as our lab and living quarters. We were able to acquire badly needed instrumentation and better and safer diving and boating equipment, transfer a dedicated assistant, Mike Carpenter, as operations manager to the program, hire Kathleen Smith as my research assistant (Figure 10), and establish a modest but cost-effective grants and fellowships fund.

The Caribbean Coral Reef Ecosystems Program is dedicated to the study of the barrier-reef complex of Belize, including its coral reefs, mangroves, seagrass meadows, and blue-water ecosystems. Instead of directing projects toward "mission-oriented"

**Figure 10.** Renovating the Carrie Bow Marine Field Station with funds from the new CCRE Program (1987); Operations Manager Mike Carpenter is installing a large storage tank for the seawater flow-through system (top). Research assistant Kathleen Smith positioning sponges for filming water-pumping activity made visible by fluorescent dye (bottom).

research, which is expensive and academically restrictive, we encourage proposals from Smithsonian staff for travel grants, and from outside collaborators nominated by Smithsonian scientists and representing complementary disciplines or having special skills. Because our funds are limited and constantly at risk of being reduced in favor of the Institution's executive priorities, proposals are competitive and rated by a program steering committee, which judges relevance to program focus, appropriateness of methods, and previous record of research production and quality. Basing project awardees at the well-equipped Carrie Bow Marine Field Station not only ensures optimum use of travel funds but concentrates research efforts on a well-defined area and stimulates scientists to discuss their results, to interact, and to collaborate. Few

bureaucrats whose primary aim is to balance their books understand that scientific results are of a far higher quality when investigations take place close to the study environment and the investigators are free to formulate their experimental designs, change project objectives if the situation so demands, interact with like-minded colleagues in an informal setting, and have easy access to functional facilities. As every CCRE participant can attest, our program has unquestionably satisfied these requirements and has done so over a sustained period for a much smaller per capita expenditure than most marine laboratories can boast of doing.

Since its inception, CCRE has made many fine contributions to science, such as the discovery of pathways of nutrient requirements of mangroves; the study of symbioses ranging form microbial associations to endobiotic shrimps societies; the assessment of coral stress, competitive threats, disease, and recovery; and installation and fine-tuning of oceanographic monitoring equipment. We are particularly proud of our environmental conservation research, which entails analysis of a marine biodiversity hotspot, the Pelican Cays reefal mangrove community in southern Belize (Macintyre and Rützler, 2000).

In December 1997, disaster struck when an accidental fire broke out in our field station's library, following a suspected short in the electric generator circuit that was abetted by insulation- devouring cockroaches and wood-destroying termites and fanned by a strong Northeaster. The fire spread rapidly through both laboratory buildings, which included the kitchen and most of our living quarters. The tremendous heat vaporized our microscopes and other scientific equipment, exploded gas cylinders, burned all our books, tools, refrigerators, and photovoltaic system, even storage tanks filled with water. All but a small cabin on the far south of the island and the separately stored boat and dive equipment were lost. Luckily, no one was injured, for only the very brave volunteer station manager, Josh White, was on the site.

My colleagues and I had several debates about where to go from there, but I do not recall a single person in favor of terminating the field operation. Therese Bowman-Rath, our local agent, and Norma Bowman, current co-owners of Carrie Bow Cay, were supportive of our plans to rebuild the station and were willing to dedicate their insurance reimbursement to this end as long as we met special construction requirements to suit the workings of a field station. We designed a new building with wet and dry laboratories, aquarium room, workshop, library, and kitchen facilities and had it built by the talented young, Cuban-born architect-builder Hedel Góngora. A three-room cabin for scientist's accommodations was added a year later. Operations manager Mike Carpenter and his volunteer station managers took care of countless finishing jobs. Despite a setback caused by the brutal forces of Hurricane Mitch in 1998, we were able to rededicate the Carrie Bow Marine Field Station in August 1999 (Figures 11, 12) and resume our dynamic research in the spring of 2000. By the time this essay is published, we will have celebrated the thirtieth anniversary of our discovery of Carrie Bow Cay and founding of one of the most successful program-dedicated coral-reef laboratories in existence.

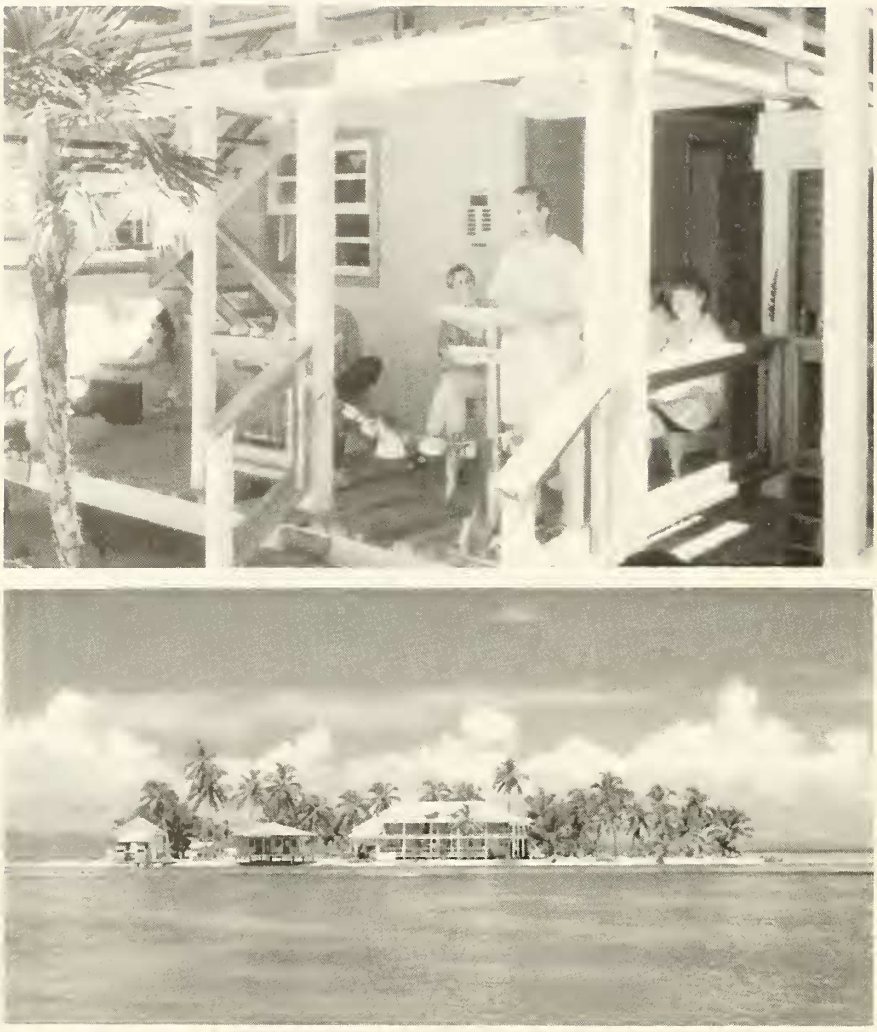

**Figure 11.** Concluding remarks at the rededication ceremony in the entrance of the new laboratory building of the Carrie Bow Marine Field Station (August 1999); looking on: Barbara Schneider (left), representing the Smithsonian Provost, and Paula DePriest (right), representing the Natural History Museum's Senate of Scientist (top). Carrie Bow Cay and the completed new field station (2001) looking southwest (bottom).

## CONCLUSION

When my teacher Rupert Riedl was still a rising marine biologist at the University of Vienna and not yet "The Master" (as we students used to refer to him) that he would become, he once told me, over a jug of Dalmatian red wine, about a big conflict in his life. He could not decide whether to take the career path of a Charles Darwin, the evolutionary theoretician, or that of an Anton Dorn, the founder and director of the famous Zoological Station of Naples.

In the forty-some years that have elapsed since that discussion, Rupert has evolved from invertebrate systematist and morphologist to marine ecologist, evolutionary philosopher, and recognizance theoretician. One could say that he ended up

following the Darwin trail. I, on the other hand, have always liked to keep both feet anchored in reality, examining organisms and communities in situ and refining laboratory techniques, determining morphological structures and functional mechanisms, analyzing environmental needs and influences, and experimentally testing ideas on interrelations derived from observations in nature. I may also have found a niche as a guide and facilitator in a down-to-sea marine research program. Our research station may never become as famous as the Stazione Zoologica di Napoli, but it will be remembered as an efficient and highly productive operation located at the heart of a coral reef ecosystem rather than on the flank of some polluted city harbor, as many marine stations are.

**Figure 12.** It's over! With the Carrie Bow Marine Field Station rededicated, Klaus Ruetzler looking forward to another 30 years of research on the barrier-reef complex of Belize.

My research may not have broken any scientific sound barriers, but it has been, and continues to be, an honest attempt at understanding and recording conditions and processes in nature and compiling useful information about sponge biology. I hope that my practical approach has enabled me to make reasonable decisions about scientific priorities, to act as a catalyst for fruitful disciplinary collaboration, and to provide efficient facilities for all those who study biology more in praxis than in theory.

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